OXYGEN TRANSPORT AND O_2HB DISSOCIATION CURVE

INTENDED LEARNING OBJECTIVES (ILOs)

By the end of this lecture the student will be able to:

1. Describe how the oxygen is transported in the blood.
2. Define Oxygen content, oxygen % saturation & oxygen partial pressure.
3. Describe with illustration the Oxy-Hb dissociation curve.

O_2 TRANSPORT

O_2 is transported in blood in two forms:-

1- Physical solution: 1.5%

It is dissolved in plasma

It depends on blood PO_2.

At PO_2 100 mmHg about 0.3 ml of O_2 is dissolved in 100 ml blood.

2- Chemical combination with Hb: 98.5 %

O_2 bind reversibly with the ferrous ion in Hb, so the reaction is called oxygenation and not oxidation.

$HbO_2 \leftrightarrow O_2 + Hb$

O_2 content of the blood :

The actual amount of O_2 which is present in 100 cc of arterial blood

= dissolved O_2 + O_2 combined with Hb

= 0.3+ 19.5

= 19.8 ml/100 ml.

O_2 carrying capacity of the blood:

The maximal amount of oxygen which can be carried by Hb when it is fully saturated.

Each gm Hb when it is fully saturated can carry 1.34 ml O_2

= Hb (15) X O_2 / 1 gm Hb

=20.1 ml O_2/100 cc blood.

<u>O_2% saturation:</u>

$$= \frac{O_2 \text{ content}}{O_2} \times 100$$

Normal saturation of arterial blood is 97.5%

It is determined by PO_2 which is related to the concentration of dissolved O_2

<u>Coefficient of oxygen utilization:</u>

$$= \frac{\text{Oxygen utilized by}}{\text{Oxygen}} \times 100$$

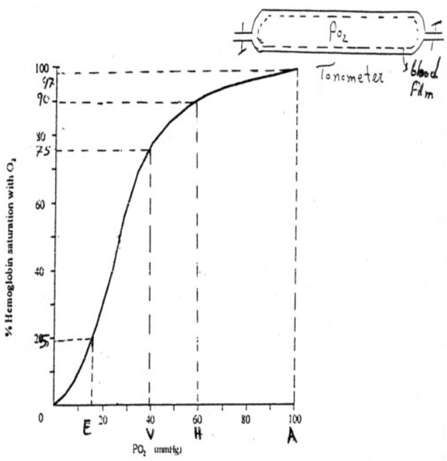
It is 25 % during rest and 75 % during exercise.

<u>Oxygen partial pressure (PO_2):</u>

The pressure exerted by O_2 when it present in a gas mixture

Partial pressure = the total pressure (P) X the fractional concentration of O_2 (PF)

O_2-HB DISSOCIATION CURVE



It is drawn using a Tonometer, which measures O_2 content at different O_2 tension.

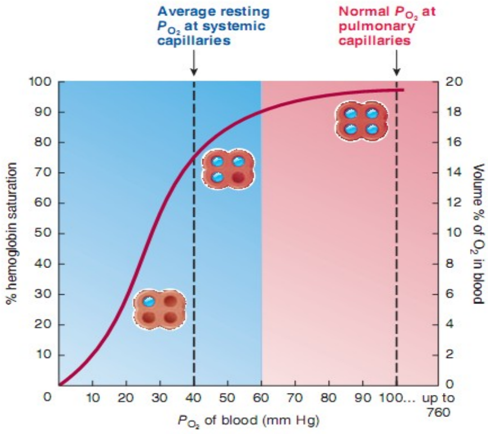
<u>The curve is S shaped as:</u>

A = arterial blood (PO_2 =100 mmHg ,O_2 saturation =97%).

H= high altitude, PO_2 decreased down to 60 mmHg but O_2 saturation decreased only to 90%.

V = Venous blood (PO_2 = 40, O_2 saturation =75%)

Thus O_2 dissociation during rest =25%.



E= muscular exercise (PO_2 = 15,O2 saturation = 25%).

Thus oxygen dissociation during exercise = 75 %.

Physiologic significance of the upper flat part of the curve:

If arterial PO_2 falls from 100 to 60 mmHg, Hb saturation decreases only from 97.5% to 90%.

So, considerable reduction in O_2 tension below the normal arterial value does ***not*** significantly reduce the oxygenation of arterial blood.

This ensures the ability to survive at high altitude or in pathological conditions as pulmonary diseases characterized by defect in ventilation, perfusion and gas exchange.

Physiologic significance of the steep lower part of the curve:

- It lies in blood PO_2 range from 0 to 60 mmHg, e.g. at tissue levels
- Within this range a small drop in PO_2 causes marked drop in Hb saturation. So, large amount of O_2 is released to tissue.
- At Venous blood (PO_2 = 40, O_2 saturation =75%). Thus O_2 dissociation during rest =25%, with adequate supply to tissues with O_2

At PO_2 below 40 mm Hg as in muscular exercise, Hb saturation decreased markedly thus releasing more O_2 to tissue.

The steep portion is important at tissue level as in this rang, small drop in PO_2 causes release of large amount of O_2 to meet the tissue requirement.

SUGGESTED TEXTBOOKS

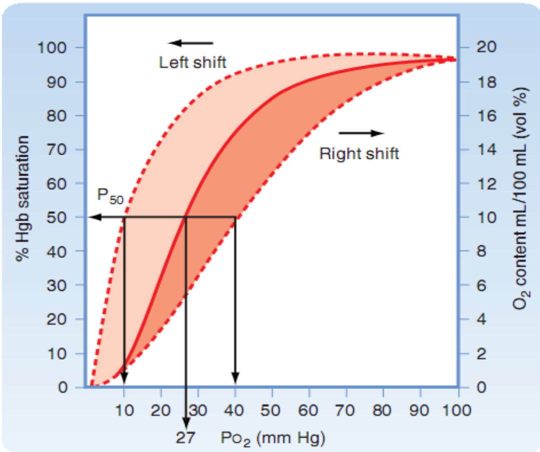
1. Guyton and Hall textbook of medical physiology, thirteenth edition 2016, Elsevier, chapter 41, from page 528 to 531

2. Ganong's Review of Medical Physiology, twenty-fifth edition 2016, McGraw-Hill Education, chapter 35, from page 639 to 640
3. Lauralee Sherwood Human Physiology: From Cells to Systems, Ninth edition 2016. CENGAGE, chapter 13, from page 450 to 456

INTENDED LEARNING OBJECTIVES (ILOs)

By the end of this lecture the student will be able to:

1. Define P50.
2. List and describe the factors that affect the position of Oxy-HB dissociation curve.
3. Describe the significance of 2,3 DBG in O_2 transport.
4. Explain the effects of fetal Hb & CO poisoning on HB affinity to oxygen.



5. Describe the myoglobin dissociation curve.

P_{50}:

- It is the value of PO_2 at which the blood is 50% saturated with O_2.
- Normally P_{50} = 26-28 mmHg.
- P_{50} is an inverse function of Hb affinity for O_2
- Increased P_{50} means the curve is shifted to the right and decrease Hb affinity to O_2 and vice versa.

<u>Shift to the Right</u>

Decrease the affinity of Hb to O_2 leading to increase O_2 delivery to tissues. Which caused by:

1-Fever.

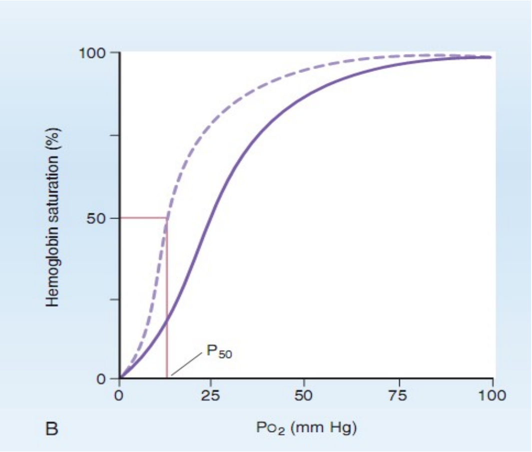
2-Acidosis.

3-Increase CO_2.

4-Increase 2,3 DPG.

5-Muscular exercise.

6-Maternal Hb._



<u>Shift to the Left:</u>

Increase the affinity of Hb to O_2 leading to decrease O_2 delivery to tissues. Which caused by:

1-Hypothermia.

2-Alkalosis.

3-Decrease CO_2.

4-Decrease 2,3 DPG.

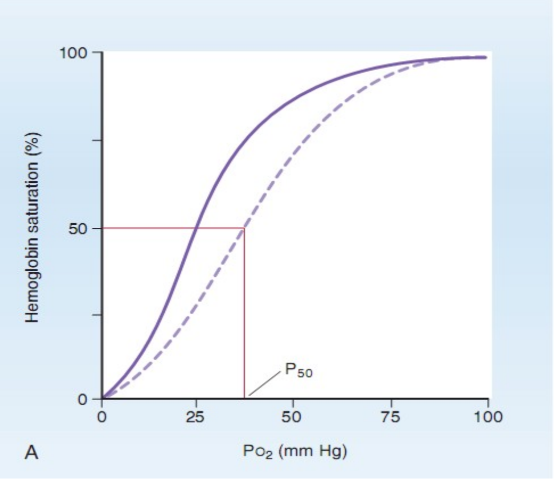
5-Foetal Hb (no β chain).

6-CarboxyHb(CO).

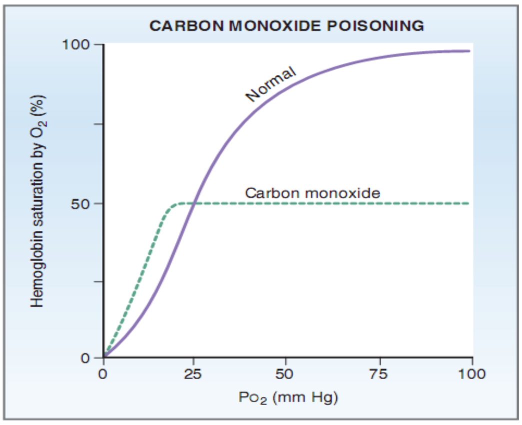
7-MetHb (oxidation)

<u>2,3 diphsphoglycerate (2,3 DPG):</u>

- Is formed by anaerobic glycolysis inside RBCs.
- It bind reversibly to **β** chain of adult Hb, decreasing its affinity to O_2 and causes shift of O_2 Hb curve to the right
- It is increased in muscular exercise, hyperthyroidism and chronic hypoxia.

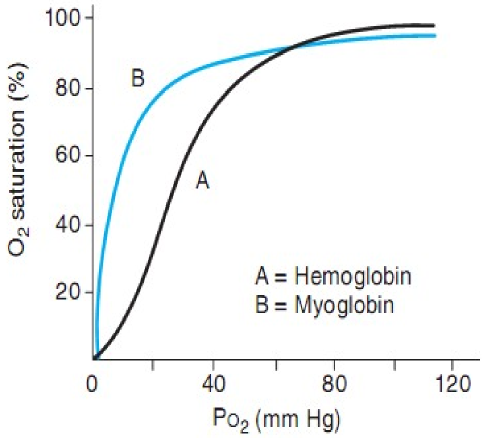


- It is decreased in deep sleep, stored blood ,acidosis and CO poisoning.



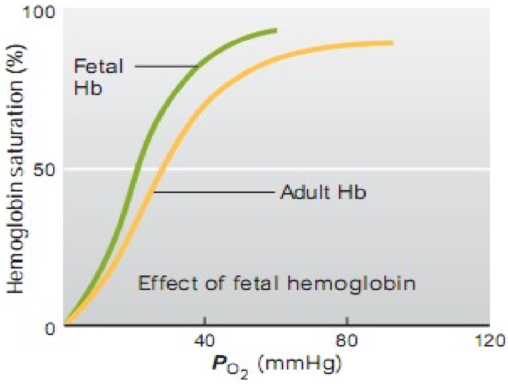
Fetal blood:

- Has high affinity for O_2, facilitating O_2 transport from mother to fetus.
- Fetal blood contains less O_2 and less CO_2 than the maternal blood.
- HbF has 2 γ chains (no **β** chains), so it binds less effectively to 2,3 DPG than HbA.



CO poisoning:

- CO binds to Hb at the same site as O_2 and forms carboxyhemoglobin (HbCO).
- The affinity of Hb to CO is higher than O_2
- CO enhances the affinity of Hb for O_2. This causes the dissociation curve to shift to the left.
- These two effects of CO are catastrophic for O_2 delivery to tissues. As there is reduction in both O_2-binding capacity of Hb and O_2 release to tissues.



OXYGEN - MVOGLOBIN CURVE

- It is rectangular in shape.

- It is to the left when compared with hemoglobin demonstrates a higher affinity for O_2, and thus promotes a favorable transfer of O_2 from hemoglobin in the blood.
- The steepness of the myoglobin curve also shows that O_2 is released only at low PO_2 values. Thus, it acts as a store of O_2 to be available in anaerobic conditions.

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2. Ganong's Review of Medical Physiology, twenty-fifth edition 2016, McGraw-Hill Education, chapter 35, from page 640 to 642

3. Lauralee Sherwood Human Physiology: From Cells to Systems, Ninth edition 2016. CENGAGE, chapter 13, from page 472 to 475